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MITIGATING CONSTRUCTION FAULTS IN COASTAL APARTMENT BUILDINGS: A CASE STUDY OF APARTMENTS OF, KARACHI CITY, PAKISTAN

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Abstract

Karachi is largest city of Pakistan, and it is experiencing rapid urbanization and apartments demand, particularly along its coastal. However, apartment buildings in these areas face significant challenges due to harsh environmental conditions such as high humidity, saline air, and extreme weather.

This study investigates the common exterior and interior construction faults in coastal Apartments, located near Karachi's Seaview coastline. Using multi-method techniques including, resident and expert questionnaires, field surveys, the research identifies common construction issues such as water seepage, rusting, plaster cracks, and poor interior finishes. Results reveal that the primary causes include substandard material use, lack of waterproofing, and poor workmanship, all exacerbated by Karachi's coastal environment.

The study proposes strategic solutions including the use of corrosion-resistant materials, enhanced construction supervision, and climate-adaptive design methods. These recommendations aim to improve construction quality, reduce long-term maintenance costs, and ensure safer, more durable coastal housing in Karachi and other coastal areas.

INTRODUCTION

The movement of people to cities and the growing interest in living by the sea have led to more apartment buildings being built along coastlines worldwide. Coastal regions offer unique aesthetic and economic opportunities, but they also tough conditions because Constant interaction between land and sea creates harsh conditions and buildings face environmental conditions, such as high winds, salt-laden air, high humidity, and the threat of extreme weather events like hurricanes, cyclones, and tsunamis.

Construction faults ranging from design flaws and material misapplications to poor workmanship and inadequate oversight are a persistent issue in the built environment. In coastal zones, the consequences of such faults are exacerbated by the environment, leading to accelerated deterioration, structural failures, increased maintenance costs, and even catastrophic losses. Therefore, mitigating construction faults in coastal apartment buildings is not merely a matter of quality assurance; it is a critical aspect of environmental resilience, occupant safety, and economic sustainability (FEMA, 2010).

Coastal apartment buildings often serve as primary residences, vacation homes, or investment properties for diverse populations. The expectation for these buildings is not only comfort and luxury but also long-term performance in the face of relentless environmental aggressors. The construction industry must, therefore, address issues such as corrosion of

reinforcement, moisture ingress, foundation instability, and material degradation more stringently in these locations. The failure to mitigate construction faults in these harsh environments can lead to rapid deterioration of structural components, water pressure leading to mold and health issues, and, in the worst cases, collapse during extreme events (Gedeon, n.d.2011).

Furthermore, studies have shown that poor housing conditions are associated with a wide range of health issues, including respiratory diseases, cardiovascular diseases, injuries, and mental health problems. The World Health Organization emphasizes that the quality of housing has major implications for people's health (World Health Organization, 2018).

However, In Karachi, common building defects, such as leakage due to plumbing issues, have been identified as significant threats to structural integrity. These defects necessitate costly repairs and compromise occupant comfort (All Pak Properties,2024).

Therefore, by investigating the root causes of these faults and evaluating existing practices, the study seeks to propose proactive measures to enhance construction quality, reduce faults, and ensure the structural integrity and safety of Apartments of, Karachi city, Pakistan.

I. Literature Review

Globally, coastal regions face rapid urban growth and development, especially regarding heavy composite structures like high-rise apartment buildings (UNEP, 2020). Construction projects are necessarily multidisciplinary and involve several consultants and contractors. An appreciation of design philosophy and construction methods are the primary factors that determine project success, as understood by several team players (Love and Smith, 2003).

Durability of masonry and steel elements in coastal environments has been discussed, with descriptions of service life prediction and maintenance actions for building envelopes (Dias, 2008). There is an urgent demand for coastal engineering practice under high uncertainty levels, with coastal engineers assessing climate change impacts and designing adaptation solutions (Losada et al., 2018). Failures in construction industry components have been investigated, with recommendations to prevent recurrence of failures provided (Mukhopadhyay, 2018).

The integration of marine and coastal management with land use planning is noted, with a shift in coastal policy towards sustainable economic growth in Scotland (Crawford, 2019). Design errors in newly constructed apartments have been identified, with end user satisfaction levels assessed through surveys and questionnaires (Noman et al., 2020). Furthermore, the other researchers are described in Table 1.

However, this study highlights the common exterior and interior construction faults of the coastal area of Karachi through perception of end users and experts. And the main agents of these faults, however, this research gives suggestions to mitigate these faults.

S. No.	Authors	Year	Findings
1.	Luis, F., Rincon., Yina, M., Moscoso., Ameur, El, Amine, Hamami., José, C., Matos., Emilio, Bastidas-Arteaga. (2024).	(2024).	Found that Analyzes factors affecting coastal structure performance and maintenance
2.	Graham, J.	(2023).	BIM reduces errors through better project coordination.
3.	Noman, A. shah R., Shaikh, ahad and Chandio, I.A.	(2020).	Concludes that Identified design errors in newly constructed apartments. Assessed end user satisfaction level through surveys and questionnaires
4.	Larsen, K.R.	(2020)	Concluding that, Corrosion of reinforcement significantly reduces structural strength, leads to cracking and spalling, and accelerates deterioration in reinforced concrete buildings.

Table 1: Related Studies

II. Methodology

This study is based on identifying the common exterior and interior construction faults and their main agents of faults of coastal areas. The aim is to propose proactive and effective strategies for mitigating exterior and interior construction faults. For this purpose, step by step methodology was adopted. Initially the common exterior and interior faults were studied from field visit and literature. After reviewing this, the questionnaire was prepared in three different parts. The first part was demographic, the second part includes common interior and exterior faults, and the third one includes open handed questions for suggestions. The respondents were selected from the residents of the coastal area of Karachi and experts (Architect, consultant, and contractor) to know the common faults and their impact. The data was analyzed in SPSS Descriptive and Cronbach's Alpha test to know the reliability of questionnaire. Fig. 1 elaborate the working methodology of this research work.

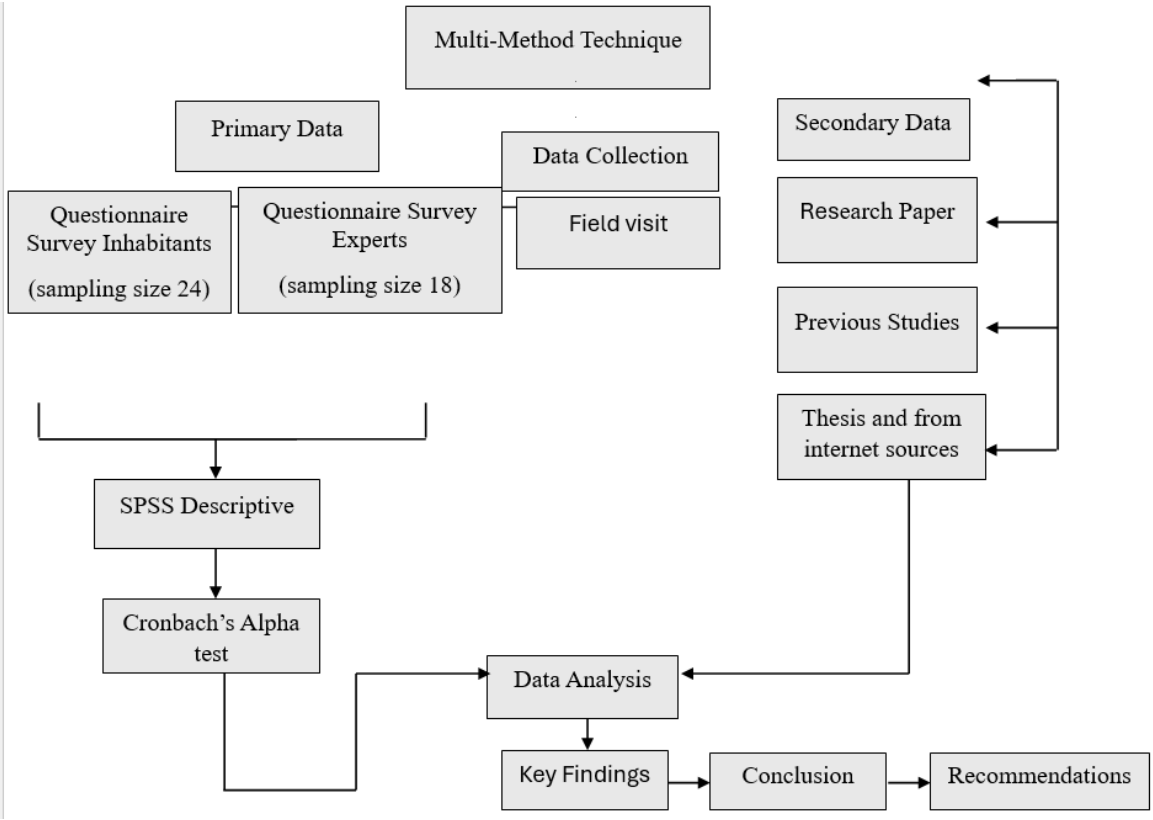


Fig.1: Working Methodology of Research

III. Result and discussion

The questionnaire designed for end users (Residents of Coastal Apartments in, Karachi, Pakistan.) and for experts (Architects, Engineers, and contractors). To determine the common exterior and interior construction faults a structured questionnaire was designed for residents and for experts in which common external and internal construction faults questions were asked from end users as well as from experts. The questionnaire included items related to visible damage and performance issues, which includes:

- Cracks in external walls and rusting of external metal elements.
- Interior wall cracks, peeling paint, and mould growth
- Water seepage, decay in structural components, and corrosion due to salt-laden air.
- Rusty window/door frames and signs of termite infestation.

Fig.2: Evidence of Exterior Condition of Coastal Apartments Karachi, Pakistan

Fig.3: Evidence of Plaster Cracks in Coastal Apartments Karachi, Pakistan

Fig.4: Evidence of Plaster Cracks in Coastal Apartments Karachi, Pakistan

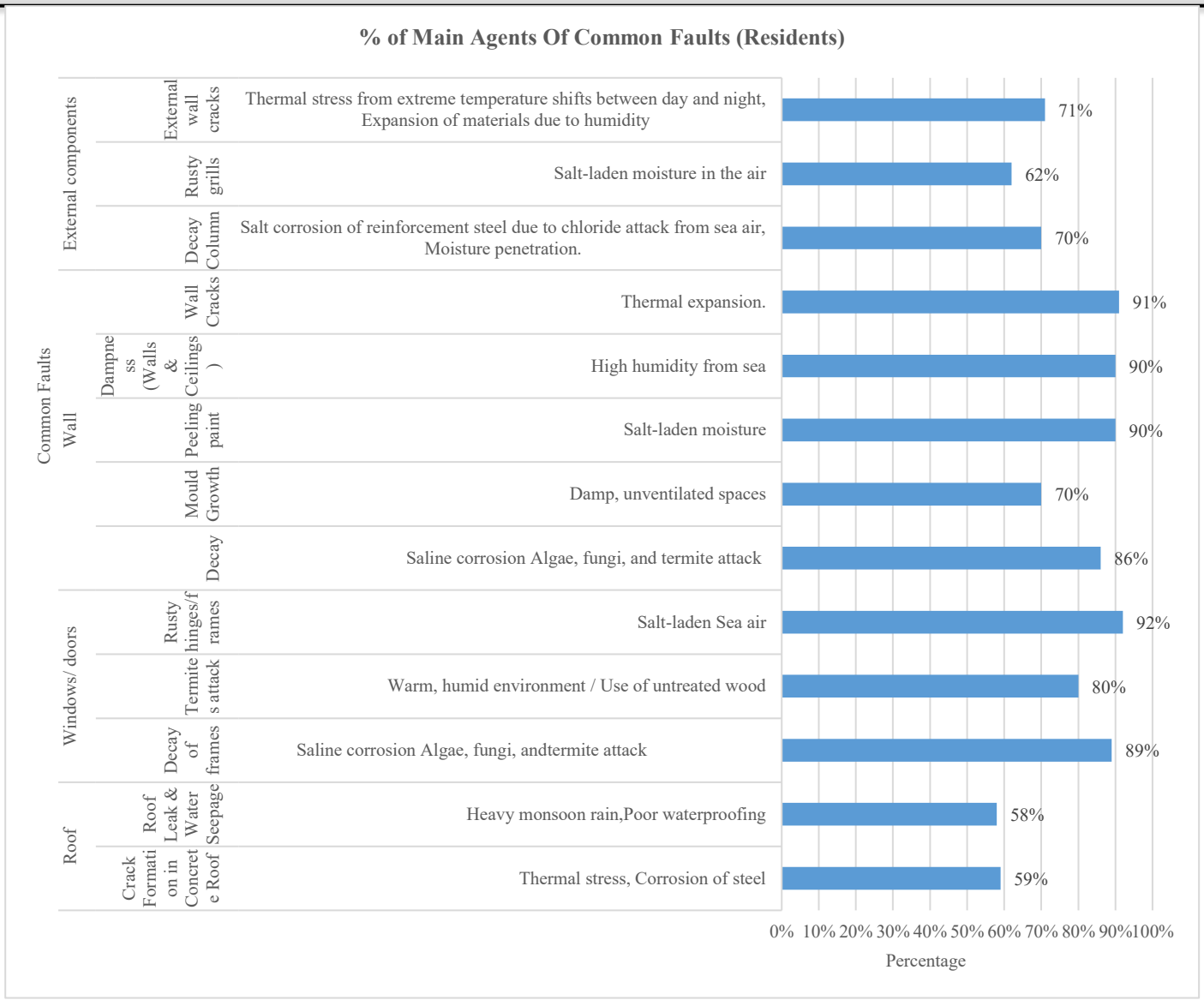
Fig.5: Evidence of Water Seepage in Coastal Apartments Karachi, Pakistan

Fig.6: Evidence of Water Seepage in Coastal Apartments Karachi, Pakistan

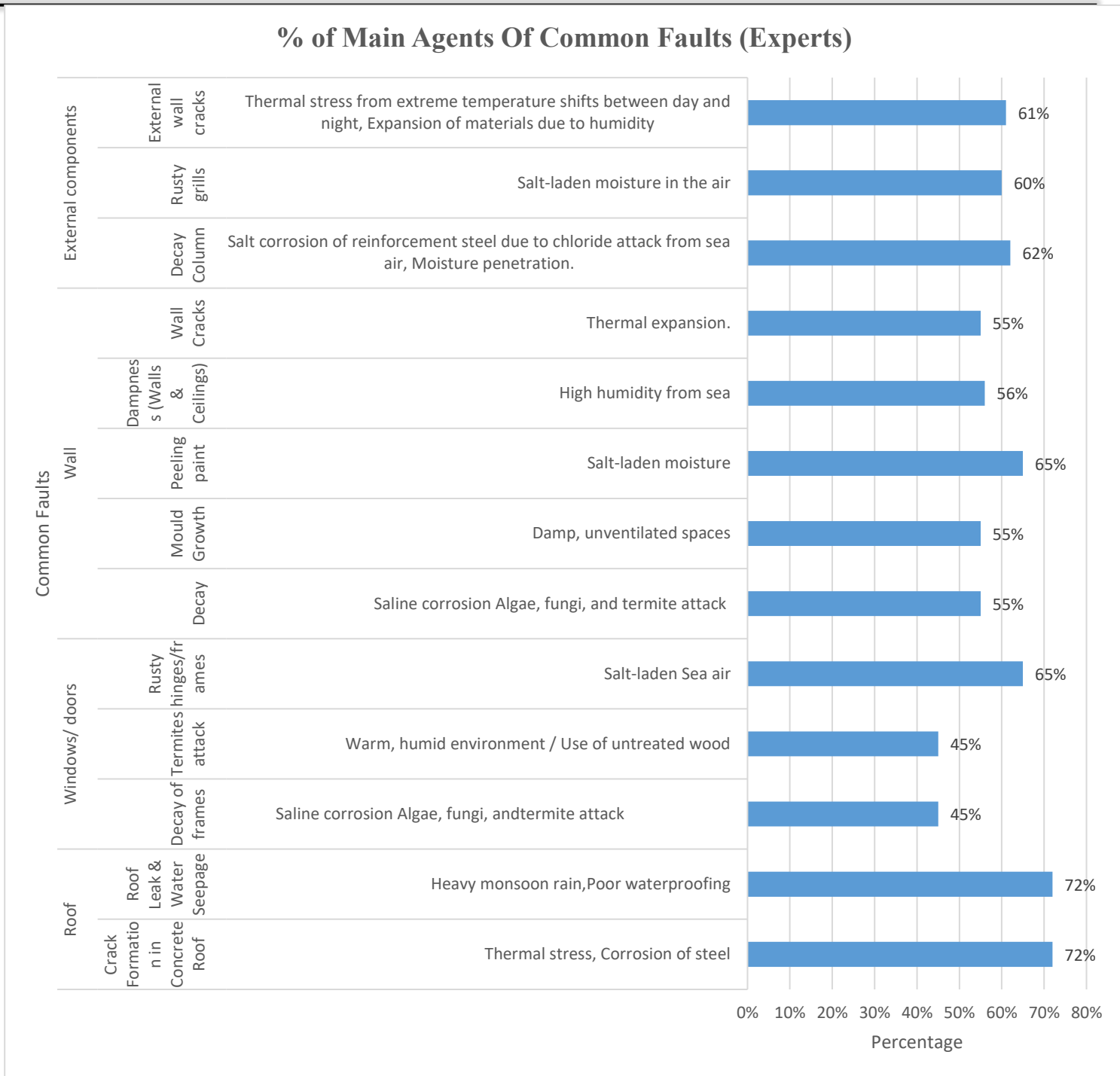
Fig.7: Evidence of Rust on Grills in Coastal Apartments Karachi, Pakistan

Components	Common faults	Main Agents	Key Effects	Resident & Expert Responses in percentage %	
External components	Decay Column	Salt corrosion of reinforcement steel due to chloride attack from sea air, Moisture penetration.	Structural failure risk, Load-bearing capacity reduction.	70.8%	61%
	Rusty grills	Salt-laden moisture in the air	Metal weakening, Safety hazard and aesthetic issues	62%	60%
	External wall cracks	Thermal stress from extreme temperature shifts between day and night, Expansion of materials due to humidity	Water seepage Deterioration of facade and structure	71%	62%
Internal components					
Wall	Wall Cracks	Thermal expansion	Water ingress	91.7%	55.6%
	Dampness in wall	High humidity from sea	Structural weakening	90%	56 %
	Peeling paint	Salt-laden moisture	Aesthetic damage, Surface exposure	90%	65 %
	Decay in wall	Saline corrosion Algae, fungi, and termite attack	Material disintegration, Reduced structural lifespan	86%	55.6%
	Mould Growth	Damp, unventilated spaces	Health issues	70%	55.6%
Windows/ doors	Rusty grills	Salt-laden Sea air	Corrosion of steel/grills	92%	65 %
	Termites attack	Warm, humid environment / Use of untreated wood	Damaged wooden component	80%	45%
	Decay in windows	Saline corrosion Algae, fungi, and termite attack	Material breakdown, Reduced load-bearing capacity	89%	45%
Roof	Roof Leak & Water Seepage	Heavy monsoon rain, Poor waterproofing	Damp ceilings, Structural weakening	58%	72%
	Crack Formation in Concrete Roof	Thermal stress, Corrosion of steel	Water infiltration, Risk of roof failure	59%	72%

Table 2: shows Results of Common Construction Faults of Residents of Coastal Apartment and Experts



Bar Chart 1: shows %age of Main Agents of Common Construction Faults of Resident of Coastal apartment



Bar Chart 2: shows %age of Main Agents of Common Construction Faults of Experts

Cronbach's Alpha:

Cronbach's alpha has become the standard on which the reliability of such measurements is judged. However, to quote the famous author, 'The numerous citations to my article by no means indicate that the person who cited it had read it' (Cronbach & Shavelson, 2004).

Statistically, to ensure the validity of questionnaire for residents and for experts Cronbach's Alpha tests were conducted by using SPSS software. This test

measures the validity of the whole questionnaire, A Cronbach's Alpha value above 0.70 is generally considered as acceptable and .90 considered as an excellent means.

Table 3: shows Reliability of Resident Questionnaire Survey

Reliability statistic	
Cronbach's Alpha	Value
	0.970

Table 4: shows Reliability of Expert Questionnaire Survey

Reliability statistic	
Cronbach's Alpha	Value
	0.974

IV. Conclusion

Based on the data collected from surveys questionnaire, several construction faults were identified in both the exterior and interior of the coastal Apartments of Karachi. According to residents, common interior issues include wall cracks, dampness, paint peeling, and termite infestations Exterior issues such as structural decay, roof leakage, and rusty grills were also widely reported. From the experts' perspective, these problems often stem from poor material selection, insufficient waterproofing, and lack of regular maintenance.

V. Recommendations

To resolve the exterior and interior construction faults of coastal Apartments, this study has suggested some recommendations which are as follows.

- Building Information Modeling (BIM) for accurate 3D visualization and clash detection.
- Apply high-performance waterproofing material on roofs, terraces, and bathroom floors. Such as Fabric cement board,
- Use weatherproof paints and coatings to protect walls from humidity. Such as acrylic paints for exterior and epoxy for interior.
- Incorporate proper slope and drainage in roofs and balconies to prevent water pooling.

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